

Arth Ganga: A Sustainable Model for Ganga River Rejuvenation

Puja Pal

Keywords: Arth Ganga, Ganges River, River Restoration, Water Management, Sustainable Development.

Abstract:

Ensuring the sustainable growth of the Ganga River is an imperative undertaking that addresses environmental, social, and economic obstacles. The Ganga holds immense cultural and economic significance in India, but it is plagued by several problems, including pollution, excessive water extraction, and habitat deterioration. The Indian Central Government intends to transition from the Namami Ganga Project to the Arth Ganga Project. This shift aims to promote the sustainable development of the Ganga River and its surrounding territories by emphasizing the economic and developmental activities associated with the river. The Arth Ganga Project aims to establish an economic connection between the people of the country and the Ganga River. This study aims to thoroughly examine the Arth Ganga Project, including its idea, distinctive characteristics, objectives, and implementation strategies for the rejuvenation of the Ganga River.

Introduction:

The Ganga River, revered as the lifeline of India, has faced persistent ecological challenges due to pollution, over-extraction, and unsustainable practices (Jhariya & Kumar Tiwari, 2020; Mondal et al., 2022). In response to this critical issue, the concept of "Arth Ganga" emerges as a beacon of hope and a sustainable model for the rejuvenation of the Ganga River. The term "Arth Ganga" encapsulates a holistic approach that extends beyond the conventional understanding of river conservation, emphasizing the inseparable link between economic development and environmental sustainability (Express News Service, 2022). This book chapter delves into the multifaceted dimensions of the Arth Ganga initiative, examining its origins, objectives, and the transformative potential it holds for the Ganga basin. The introductory section provides an overview of the historical and cultural significance of the Ganga River, setting the stage for the urgent need for comprehensive rejuvenation efforts. It also highlights the environmental degradation and water quality concerns that have necessitated innovative and sustainable solutions.

Arth Ganga represents a pioneering and sustainable model for rejuvenating the Ganga River, playing a pivotal role in the circular economy. This initiative integrates environmental conservation with economic development, emphasizing the holistic management of water

Puja Pal

Assistant Professor, Department of Zoology, Taki Government College, Taki, West Bengal, India 743429

E-mail:  drpujapal.zoo@gmail.com; Orcid iD:  <https://orcid.org/0000-0002-7924-8767>

*Corresponding: drpujapal.zoo@gmail.com

resources. Arth Ganga envisions a circular economy approach by promoting responsible consumption and production, waste reduction, and the efficient use of natural resources (Express News Service, 2022). By fostering eco-friendly practices, this model not only contributes to the Ganga's revitalization but also aligns with broader sustainable development goals. It exemplifies how environmental stewardship can coexist with economic prosperity, offering a blueprint for other regions grappling with river degradation (Saha, 2023).

As we embark on this exploration, it becomes evident that Arth Ganga is not merely an environmental conservation program but a visionary strategy that intertwines ecological well-being with socio-economic development. The chapter aims to unravel the intricate layers of Arth Ganga, elucidating how it integrates sustainable practices, community engagement, and economic growth to create a symbiotic relationship between human activities and the river ecosystem. Furthermore, the introduction addresses the collaborative nature of Arth Ganga, involving stakeholders at various levels, including government bodies, non-governmental organizations, and local communities. By fostering partnerships and aligning diverse interests, Arth Ganga represents a paradigm shift in river rejuvenation efforts, emphasizing the interdependence of environmental sustainability and economic prosperity (Kumar, 2022). In essence, this chapter sets the stage for a comprehensive exploration of Arth Ganga, inviting readers to delve into a transformative model that not only seeks to revitalize the Ganga River but also strives to achieve a harmonious balance between human development and ecological integrity.

Economic and Biodiversity Potential of a River:

The biodiversity potential of each riverine ecosystem contributes to the overall value of the ecosystem services it provides. The economic potential of the system refers to the maximum value that can be obtained from it before the ecological system's collapse (Saha & Sarkar, 2022). In most instances, the overall economic potential will surpass the biodiversity potential. However, to fully maximize the economic potential, it is necessary to achieve a harmonious ecological equilibrium. Hence, it is imperative to regulate the degree of economic value extraction following a sustainable development strategy. This framework provides us with a concrete and systematic instrument to direct all development operations (Hariram et al., 2023; Srinivas et al., 2020). The River Conservation and Biodiversity components of the Ganga River Basin, as well as all other river basins, should be the central focus of all developmental operations. The accompanying image portrays the developmental and conservation goals of the river Ganga system (Das & Tamminga, 2012). This is expected to serve as a paradigmatic example of development not just for other river systems in India but also for river systems worldwide.

Restoration of Ecosystem:

Ecosystem restoration involves helping deteriorated or destroyed ecosystems recover and preserving intact ecosystems (Saha & Sarkar, 2022). Richer biodiversity makes ecosystems more fruitful, generates more wood and fish, and stores more greenhouse gases (Shivanna,

2022). Actively planting or reducing pressures to let nature recover are strategies to restore. It's not always possible or desirable to restore an environment. Farmland and infrastructure are still needed on forest land, and ecosystems, like societies, must adapt to climate change (Gann et al., 2019). Restoration of 350 million hectares of damaged terrestrial and marine ecosystems might provide US\$9 trillion in ecosystem services by 2030. The atmosphere might lose 13 to 26 gigatons of greenhouse gases via restoration (UNEP, 2019). Inaction is at least three times more expensive than ecosystem restoration, although such interventions have economic rewards nine times greater than investment (Alikhani et al., 2021). Rivers, forests, farmlands, cities, wetlands, and seas may be restored (Figure 1).

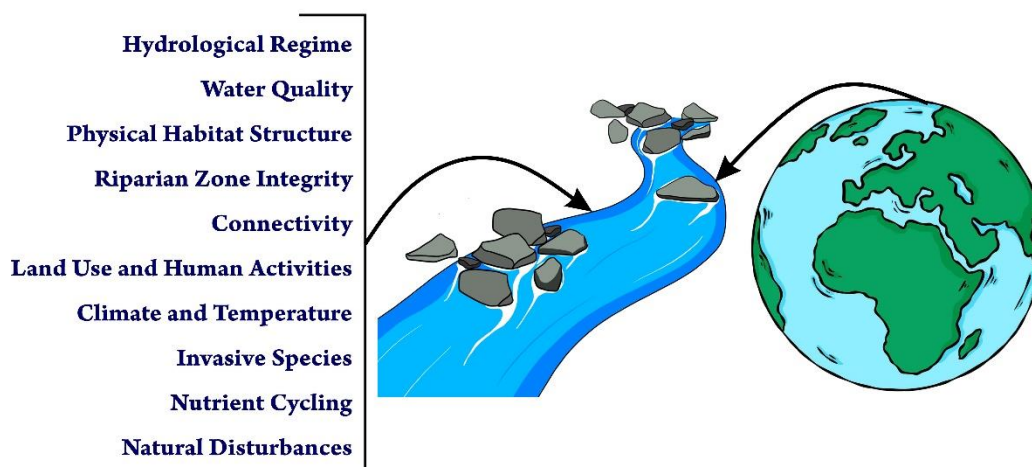


Figure 1. Riverine Biodiversity and its Influencers.

Over the past several decades, numerous significant aquatic species (fishes, dolphins, gharials, turtles, etc.) have perished from the Ganga (Saha & Sarkar, 2022). Now, a river ecosystem's inherent biodiversity is vital to the river basin's functional health and ecosystem services. To comprehend biodiversity changes in the National River Ganga and find ways to restore its ecological balance, one must study the River Ganga ecosystem's dynamics and analyse human and non-anthropogenic influences (Singh & Singh, 2020). Living species (plants, animals, and bacteria) interact with non-living environmental components in an ecosystem. Biological and abiotic components are connected via nutrient cycles and energy fluxes. Photosynthesis provides energy and carbon, while mineral nutrients are recycled. External variables (temperature, geological material, geography, and time) and internal factors (decomposition, periodic disturbances, species competition, and human activities) now regulate ecosystems. Since ecological processes are driven by species kinds, numbers, and relative abundances, species biodiversity is vital for ecosystem functioning (Chakraborty et al., 2023). Ecosystems can be assessed by their benefits to people or by their "ecosystem structure" (measurable qualities of a least damaged or reference state) (Sturbois et al., 2023). Ganga is a varied landscape-scale ecosystem. First, the river crosses three climatic-geographical zones: snow-clad and alpine Himalayas, tropical alluvial plains, and estuary zone and sea. River

Ganga's ecology depends on basin variety within each climate zone (Sharma et al., 2022). The river's ecosystem border may be the river banks, but its biotic and abiotic interactions with its riparian zones, flood plains, and drainage basin are frequently close. The saturated subsurface zone under the river bed forms a unique habitat (called a “hyporheic biotope”) for a diverse group of fauna, provides temporary refuge for aquatic organisms in times of trouble, and processes river nutrients and interacts with groundwater (Chandra & Zoological Survey of India, 2022). Many animals from far and near visit the National River Ganga and its tributaries, which are home to a diverse range of aquatic life from microscopic flora and fauna to larger invertebrates and vertebrates (De et al., 2023).

Potential challenges and threats to the biodiversity of River Ganga:

Human needs have led to the exploitation of riverine ecology. Ecological integrity is being affected and disturbed by significant threats to the Ganga basin and other river basins across the nation (Gupta, 2021).

Disintegration of River Habitats and Alterations to the Flow Regime:

The number of run-of-the-river (ROR) hydroelectric projects in the headstreams of the Ganga has altered the flow patterns. This has resulted in the fragmentation of habitats and changes in the flow regime. These hydroelectric projects have fragmented the river, making it impossible for some important fish, such as *Schizothorax sp.* and *Tor sp.*, to migrate. It is crucial to ensure that the Ganga River network is longitudinally connected and that there are sufficient water and silt flows (Vyas et al., 2023; Kala, 2011).

Alterations in river habitat:

The river's environment and form also change over time due to shifts in the flow regime. Erosion, channelization, and river realignment have resulted from changes in flow direction caused by large-scale gravel and sand mining, dumping of building wastes, and other solid wastes (Jaiswal et al., 2021). These changes alter the flora in floodplains and narrow the stream. Changes in habitat have a devastating effect on the ecosystem. Modifications to benthic flora and fauna, fish breeding grounds, and turtle nesting locations are all results of habitat modification (Jaiswal & Pandey, 2021).

Shrinkage in river habitat:

The ecosystem of river species is experiencing a decline as a result of significant human-induced water diversion from the Ganga River Network throughout the basin. The diversion of river movements is facilitated by several dams and barrages. During wet seasons, river water abstractions are moderate, while during dry flow seasons, they are substantial. Flows through the river channel are significantly diminished during the dry season but remain nearly constant at high levels during the rainy season (Sinha & Kannan, 2014). Over the past two centuries, urbanization and land-use changes in several regions may have increased the rate of peak

discharge from the basin into the rivers, thereby elevating river flood peaks. Overall, the hydrological extremes of the river have intensified, thereby increasing the survival pressure on the biota (Amarasinghe et al., 2016).

Riverine Pollution:

The Ganga River downstream of Haridwar is significantly polluted by industrial and domestic pollutants. The pollution reaches a concerning level below Kannauj, specifically at the confluence of the Ramganga and Kali rivers and continues to the least of Varanasi. Extremely high concentrations of pollutants in a river are lethal to its biota (Bhattacharya et al., 2016; Sanyal et al., 2017; Singh et al., 2022).

Invasion of exotic species to river habitat:

Below Prayagraj, the Ganga is invaded by exotic fish such as common carp (*Cyprinus carpio*) and Tilapia (*Oreochromis niloticus*). These fish entered the Sangam through the Yamuna and have proliferated from Prayagraj to Bhagalpur and beyond. They surpass Indian Major Carps (IMC) due to their adaptability to fluctuating flows (Singh et al., 2010). Nine exotic fish species, including Nile tilapia, Thai magur, and grass carp, have been identified in the Ganga. However, the invasion is not limited to the middle and lower reaches. The sighting of another alien fish, the brown trout (*Salmo trutta fario*), downstream of Jhala indicates invasive species presence up to Bhagirathi (Das et al., 2022). Manmade river modifications, to which indigenous species are not acclimated, often give invasive species a competitive edge in river ecosystems. The invasion of exotic species into the Ganga River Network habitat is also a result of human activities. These invasions propagate new illnesses and parasitic organisms, disrupting river ecology. Therefore, it is crucial to control or eradicate the exotic species that have entered the river network (Choudhary et al., 2023; Mukherjee et al., 2022; Sanyal et al., 2023).

Riverine habitat infringement:

From ancient times, humans have utilized floodplains and riverbanks for various purposes. However, contemporary constructions on floodplains and farming on riverbeds during lean flow seasons have led to increased encroachments. The surge in construction on floodplains has modified runoff patterns into rivers, escalated pollution inflows with runoff, diminished groundwater recharge and base flows in rivers, and severed ecological linkages between rivers, floodplains, and floodplain wetlands (Serra-Llobet et al., 2022). Farming on riverbeds and the use of modern chemical pesticides like DDT and HCH have resulted in the contamination of the riverbed, causing harm to aquatic organisms, particularly hyporheic biota, and disrupting upper aquatic animal mating sites (Rad et al., 2022).

Anthropogenic nutrient shortage:

Anthropogenic nutrient shortages in the River Ganga ecosystem have received less attention than anthropogenic pollution. Anthropogenic influences on river nutrient concentrations are called nutrient enrichment, which increases nitrogen (N), phosphorus (P), and other nutrients found in agricultural, household, and industrial wastewaters. Conversely, nutritional deficiencies are commonly missed (Bowes et al., 2020).

Ecosystem Restoration Measures under Namami Gange:

Introduction to Arth Ganga: The Namami Gange campaign, led by the National Mission for Clean Ganga (NMCG), is dedicated to the conservation of the Ganga River and its tributaries. The primary objective of NMCG is to rejuvenate the river, ensuring a continuous and unpolluted flow (Aviral and Nirmal Dhara) while preserving its geo-hydrological and ecological integrity. The holistic approach and innovative features embedded in Namami Gange have positioned it as a pioneering river rejuvenation program, encompassing various aspects such as policy-making, project management, financial planning, investment sustainability, scientific research, knowledge management, institutional development, basin management, and planning (Koshy, 2023). Despite the ambitious goals of river rejuvenation, a significant challenge arises from the lack of scientific evidence, necessitating intensive research investigations. In response to this concern, NMCG has approved basin-based river rejuvenation research programs, as highlighted in the National Mission for Clean Ganga's 2020 report. These research initiatives cover a wide range of subjects, including history, culture, ecology, science, and technology. During a formal virtual presentation at World Water Week 2022 in Stockholm on August 24, 2022, Mr. G. Asok Kumar, Director General of NMCG, discussed the Arth Ganga project. The Arth Ganga initiative focuses on economic and developmental activities related to the Ganga, aiming to sustain the development of the river and its surrounding areas (PIB, 2022).

History and objective of Arth Ganga Project:

The Prime Minister of India announced the concept of Arth Ganga during the inaugural National Ganga Council meeting in Kanpur in 2019. He emphasized the need to shift from the Namami Ganga initiative to the Arth Ganga project model. The primary objective of the Arth Ganga project was to promote sustainable development of the river Ganga and its surrounding communities via targeted economic and developmental initiatives. The Arth Ganga Project tries to use economics to bridge the country's people with the river Ganga. Arth Ganga is targeted to contribute at least 3% of the GDP (Gross Domestic Product) from the Ganges Basin itself, and the Arth Ganga project's plans are aligned with India's commitments toward the UN sustainable development goals (SDGs) (DD News, 2019).

Salient features of the Arth Ganga Project:

Six verticals have been proposed (Figure 2) to fulfil the objectives of the Arth Ganga Project, as outlined by PIB (2023):



Figure 2. Six Verticals of Arth Ganga Project.

- The initial component is Zero Budget Natural Farming, which entails the use of chemical-free or organic farming along a 10-kilometre stretch on both sides of the river Ganga. This initiative also aims to encourage the use of cow dung and organic waste as fertilizers through the GOBARdhan project.
- The second vertical focuses on the monetization and reuse of wastewater and sludge. This involves using treated wastewater for various purposes, such as industrial usage, irrigation, and generating revenue for Urban Local Bodies (ULBs).
- The Arth Ganga Project will include initiatives to generate livelihoods and job opportunities. This will be achieved by establishing habitats where local communities may engage in the sale of medicinal plants, products, and Ayurvedic goods.
- The fourth objective aims to enhance public engagement in the project by fostering collaboration among the stakeholders associated with the river Ganga.
- The Arth Ganga model aims to enhance and facilitate the preservation and promotion of the cultural heritage and tourism of the river Ganga and its surrounding areas. This will be achieved through activities such as boat riding, adventure sports, and the organization of yoga sessions along the riverbanks.
- The Arth Ganga model aims to enhance the institutional framework by empowering local government to effectively administer the water resources of the river Ganga.

The Unique Namami Gange Programme:

A conservation mission, the Namami Gange Programme aims to protect and revitalize the National River Ganga while simultaneously effectively controlling pollution. It was designated as the iconic "Flagship Programme" by the national government in June 2014. This falls under the purview of the Jal Shakti Ministry's Department of Water Resources, River Development, and Ganga Rejuvenation. State Programme Management Groups (SPMGs) are the federal equivalent of the National Mission for Clean Ganga (NMCG), which is implementing the Namami Ganga program. On behalf of the National Ganga Council, NMCG carries out its operational mandate (Figure 3). It comprises around 288 related projects, has a government-financed budget of Rs. 20,000 Cr, and is not a lapsable corpus. Afforestation, riverfront development, biodiversity, industrial effluent monitoring, river-surface cleaning, public awareness, and sewage treatment infrastructure are the primary goals of the Namami program (NMCG, 2020).



Figure 3. Five important pillars of Namami Gange.

The Initiatives of Arth Ganga:

Ministry of Jal Shakti, Govt. of India has proposed multiple new initiatives under the Arth Ganga Project. These are summarized below:

Jalaj Initiative:

Jalaj is being executed in collaboration with the Wildlife Institute of India. WII has established trained Ganga Prahari cadres from among the local populace to promote Ganga rejuvenation and biodiversity conservation (Mohan, 2022). The objective of Jalaj, an innovative mobile livelihood facility, is to synchronize skill development initiatives with the preservation of the Ganga. Jalaj serves as an exemplar for diversifying livelihoods by promoting locally produced goods and encouraging stakeholder engagement in ecological and economic domains to conserve rivers by the objectives of the "Arth-Ganga" initiative (WII, 2023).

Jalaj will achieve two goals: Firstly, to build 75 Jalaj for realizing Arth Ganga in the Ganga River Basin by integrating conservation and livelihoods, and secondly, to raise awareness of aquatic biodiversity conservation. The proposed initiative (Figure 4) would relate local livelihoods to Ganga River basin conservation aims to involve local populations. Local skill sets, raw materials, market, and demands will shape Jalaj's site-specific models, such as knowledge corners, livelihood training and sale points, ecotourism-based safari boats, nurseries, health and wellness centres, sewing and stitching centres, local produce-based food processing units and sale points, etc. The Jalaj model will include resources for aquatic biodiversity protection, livelihood training, and sales centres for trainees' goods (Mohan, 2022; WII, 2023).

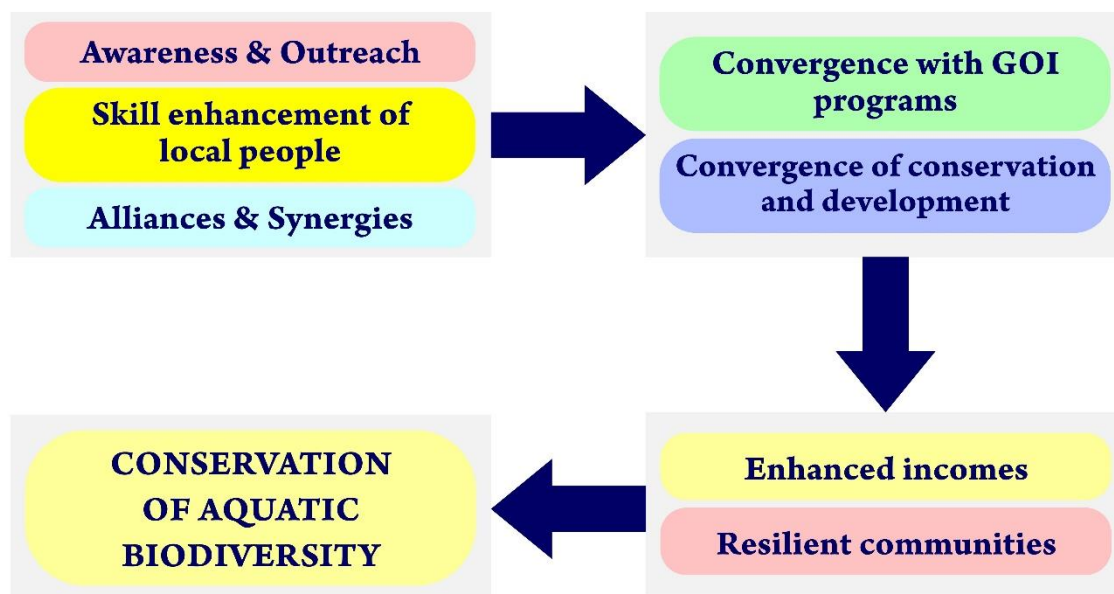


Figure 4. Steps involved in Arth Ganga implementation by WII.

Memorandum of Understanding between NMCG and Sahakar Bharati:

To accomplish sustainable and successful economic growth via public engagement, local cooperative establishment and strengthening, and Arth Ganga mission fulfillment. The MoU proposes naming 75 villages in five states on the main stem 'Sahakar Ganga Grams,' promoting natural farming among farmers, FPOs, and Cooperatives in Ganga-affected states to generate 'More Net-Income Per Drop,' facilitating the marketing of natural farming/organic produce

under the brand Ganga through market linkages and promoting people-river connections through an economic bridge (Gupta, 2022).

Introduction of ImAvatar:

ImAvatar promotes the Arth Ganga program through tourism and the marketing of local agriculture and handicrafts. NMCG and ImAvatar would collaborate on religious and spiritual tourism and market links. The partnership includes digitizing NMCG and Namami Gange's touch points and assets. The launch of the Digital Dashboard for DGCs Performance Monitoring System by the Honourable Union Minister for Jal Shakti, Shri Gajendra Singh Shekhawat on April 6, 2022, was a step towards enhancing public participation, one of Arth Ganga's goals. District Ganga Committee Forum [DGC-4M (Monthly, Mandated, Monitored, and Minuted)] meetings were started to facilitate frequent district-level engagement on Ganga issues, including all stakeholders (Srivastava, 2022).

Initiation of a new course 'River Champ' on CLAP:

Indian river conservation awareness, activities, and discussions are raised online by the continuous learning and activity site (CLAP). Ganga Quest, an online quiz, educates kids and teens about the River Ganga. The Namami Gange Continuous Learning and Activity Portal hosted the Ganga Quest 2022 (APAC, 2022).

Ganga Bhog:

The program also aims to improve the well-being of local women who farm millet by making it easier to prepare healthy 'bhog' in temples. NMCG, in collaboration with the Himalayan Environmental Studies and Conservation Organization (HESCO), has developed a project in Rishikesh called 'Ganga Bhog - Gangotri Se Ganga Sagar Tak' to raise awareness among villagers about livelihood generation. The initiative, which was inaugurated on April 22 as part of Earth Day festivities, is yet another project within the Namami Gange program's 'Arth Ganga' idea. The campaign 'Ganga Bhog' is centered on the '5 Ms': maa (mother), mandir (temple), mitti (land), Mahila (women), and mota-and (millets) (Figure 5). Local women grow millet on the lush soil of the Ganga riverbed and present it as prasad to temples along the river. According to a government news release, the project also aims to improve the well-being of local women who produce millet and to make it easier to provide healthy bhog (a communal meal or offering) at temples. This was done with the United Nations General Assembly's declaration of 2023 as the 'International Year of Millets' in mind (Mishra, 2023).

Economic activity in the light of Arth Ganga:

"Arth-Ganga" will coordinate Ganga River business activities. Developing streams affect the ecosystem and riverbanks. Shri Mansukh Mandavia remarked that executing Narendra Modi's slogan of "Reform, Perform, and Transform" will quadruple Ganga cargo capacity with a concentration on interior waterways. Arth-Ganga will enhance farmers, small traders, and

communities' economic growth and inclusion. Shri Mansukh Mandaviya, Shipping (Independent Charge), Chemicals, and Fertilisers Minister, said at the press conference that Inland Waterways is one of the most significant foundations of the “Arth-Ganga” project, which would lead to inclusive growth and huge job prospects in the National Waterways length. Shri Mandaviya observed, “Almost half of the Indian population lives around the Ganges River belt, in which about 1/5th of all India's freight originates and 1/3rd terminates in the states around the Ganges Belt.” In recent years, the Ministry of Shipping has taken many measures that have increased Inland Cruises from 3 to 9, Cargo from 30,00,000 MT to 70,00,000 MT, and Vessel’s flow from 300 to 700. The Ministry of Shipping has developed modest jetties for farmers, traders, and the public throughout the 1400 km National Waterway-1 from Banaras to Haldia. Farmers will obtain a higher return on their crops since shipping will be easier and cheaper. It will boost ‘Ease of Living’ and ‘Doing Business.’ The Inland Waterways Authority of India (IWAI) is using tiny floating jetties and ten Ro-Ro vessels to deliver commodities more efficiently and cheaply (Sagarmala, 2021). According to the report, the Ministry of Shipping is investing Rs. 200 crores in Varanasi (Uttar Pradesh) Freight Village and Sahibganj (Jharkhand) Industrial Cluster-cum Logistics Park to work with Inland Waterways. This will strengthen the local economy by creating massive direct and indirect jobs. National Waterway-1 would connect Varanasi to Nautanwa (280km), Kaughat to Raxaul (204km), and Sahibganj to Biratnagar (233km) in Nepal. Previously, Kolkata and Visakhapatnam Ports transported freight from Nepal. Under the Treaty for Transit of Cargo between India and Nepal, inland waterways, especially NW-1, would be authorized. It would reduce logistics costs and decongest Kolkata Port (Sagarmala, 2021).

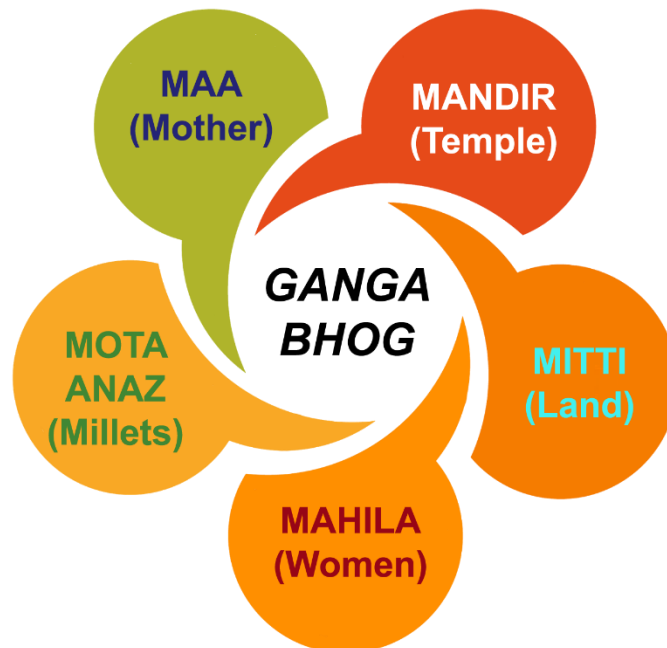


Figure 5. Ganga Bhog Concept under Arth Ganga Project.

Arth Ganga Campaign:

Clean Ganga Mission Encourages Farmers to Practice Zero-Budget Natural Farming. NMCG organized a field trip for approximately 30 farmers from the Ganga Basin (Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal) to Subhash Palekar Natural Farming (SPNF) to promote the adoption of natural farming practices as part of the Namami Gange initiative (Dwivedi, 2022). Subhash Palekar, a distinguished agriculturist recognized by the farming community as 'Krishi ka Rishi,' is well-known for his advocacy of the 'Zero Budget Natural Farming' approach, referred to as Subhash Palekar Farming in India. The workshop camp was held in August 2023. The objective of facilitating farmers for the workshop as part of the Namami Gange Programme is to effectively address the issue of polluted water from farms entering the River Ganga. Additionally, it aims to provide a viable and sustainable livelihood framework for farmers through the adoption of natural farming practices, aligning with the Arth Ganga initiative. NMCG also coordinated a training-cum-workshop event in Shirdi, Maharashtra, where farmers were encouraged to embrace zero-budget natural farming as a component of the 'Arth Ganga Campaign' (Bhagwat, 2019).

Conclusion:

In conclusion, the sustainable development of river ecosystems, such as the Ganga, demands a comprehensive and collaborative effort across various sectors. Balancing economic activities with environmental conservation is paramount to ensure the longevity of these vital waterways. The multifaceted approach of the Arth Ganga Project, as outlined in the present findings, encompasses water quality management, biodiversity conservation, water resource management, community engagement, preservation of cultural heritage, effective governance, and continuous research and innovation, providing a roadmap for achieving sustainability. The sustainable development of rivers is not merely an environmental imperative but also a prerequisite for the well-being of communities relying on these water bodies. By embracing the Arth Ganga strategies, we can strive to strike a harmonious balance between human activities and the preservation of the invaluable ecosystems that rivers represent. In doing so, we can secure a healthier, more resilient future for both rivers and the diverse life forms they support.

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References:

- Alikhani, S., Nummi, P., & Ojala, A. (2021). Urban wetlands: A review on ecological and cultural values. *Water*, 13(22), 3301. <https://doi.org/10.3390/w13223301>

- Amarasinghe, U. A., Muthuwatta, L., Smakhtin, V., Surinaidu, L., Natarajan, R., Chinnasamy, P., Kakumanu, K. R., Prathapar, S., Jain, S. K., Ghosh, N. C., Singh, S., Sharma, A., Jain, S. K., Kumar, S., & Goel, M. K. (2016). *Reviving the Ganges water machine: Potential and challenges to meet increasing water demand in the Ganges River Basin*. International Water Management Institute (IWMI). <https://doi.org/10.5337/2016.212>
- APAC. (2022). Arth-ganga initiatives launched at Yamuna par azadi ka Amrit Mahotsav. *Arth-Ganga Initiatives Launched at Yamuna Par Azadi Ka Amrit Mahotsav*. <https://apacnewsnetwork.com/2022/08/arth-ganga-initiatives-launched-at-yamuna-par-azadi-ka-amrit-mahotsav/>
- Bhagwat, R. (2019). Zero Budget farming inventor Subhash Palekar is PM Narendra Modi's go-to agri man. *The Times of India*. <https://timesofindia.indiatimes.com/city/nagpur/zero-budget-farming-inventor-palekar-is-modis-go-to-agri-man/articleshow/70097986.cms>
- Bhattacharya, P., Samal, A., & Bhattacharya, T. (2016). Sequential extraction for the speciation of trace heavy metals in Hoogly river sediments, India. *Int. J. Exp. Res. Rev.*, 6, 39-49.
- Bowes, M. J., Read, D. S., Joshi, H., Sinha, R., Ansari, A., Hazra, M., Simon, M., Vishwakarma, R., Armstrong, L. K., Nicholls, D. J. E., Wickham, H. D., Ward, J., Carvalho, L. R., & Rees, H. G. (2020). Nutrient and microbial water quality of the upper Ganga River, India: Identification of pollution sources. *Environmental Monitoring and Assessment*, 192(8), 533. <https://doi.org/10.1007/s10661-020-08456-2>
- Chakraborty, S. K., Sanyal, P., & Ray, R. (2023). Conclusion on eco-biological uniqueness of wetland ecosystem with special reference with east Kolkata wetlands, India. In S. K. Chakraborty, P. Sanyal, & R. Ray, *Wetlands Ecology* (pp. 679–705). Springer International Publishing. https://doi.org/10.1007/978-3-031-09253-4_11
- Chandra, K. & Zoological Survey of India (Eds.). (2022). *Faunal diversity of biogeographic zones of India: Gangetic plains*. Zoological Survey of India, Ministry of Environment, Forest and Climate Change, Government of India.
- Choudhary, M., Thakur, K., Brar, B., Kumar, S., Sharma, D., Kumar, R., & Mahajan, D. (2023). Status of fish assemblage structure in the Ganga and Indus riverine systems of the western Himalaya. *World Water Policy*, 9(3), 613–638. <https://doi.org/10.1002/wwp2.12116>
- Das, P., & Tamminga, K. R. (2012). The Ganges and the gap: An assessment of efforts to clean a sacred river. *Sustainability*, 4(8), 1647–1668. <https://doi.org/10.3390/su4081647>
- Das, S. C. S., Jha, D. N., Kumar, V., Alam, A., Srivastava, K., Sahoo, A. K., & Das, B. K. (2022). Fish diversity, community structure, and environmental variables of River Tamas, a tributary of River Ganga, India. *Aquatic Ecosystem Health & Management*, 25(2), 62–69. <https://doi.org/10.14321/aehm.025.02.62>

- DD News. (2019). *Pm modi chairs 1st meeting of National Ganga Council in Kanpur | dd news*. Ddnews. Gov.In; DD News. <https://ddnews.gov.in/new-india-story/pm-modi-chairs-1st-meeting-national-ganga-council-kanpur>
- De, K., Singh, A. P., Sarkar, A., Singh, K., Siliwal, M., Uniyal, V. P., & Hussain, S. A. (2023). Relationship between species richness, taxonomic distinctness, functional diversity, and local contribution to β diversity and effects of habitat disturbance in the riparian spider community of the Ganga River, India. *Ecological Processes*, 12(1), 13. <https://doi.org/10.1186/s13717-023-00421-4>
- Dwivedi, S. (2022). *Arth Ganga campaign: Clean Ganga mission encourages farmers to practice zero-budget natural farming*. Krishijagran.Com; Krishijagran. <https://krishijagran.com/agriculture-world/arth-ganga-campaign-clean-ganga-mission-encourages-farmers-to-practice-zero-budget-natural-farming/>
- Express News Service. (2022). Explained: What is ‘Arth Ganga’, the govt’s new model for the river’s sustainable development? *The Indian Express*. <https://indianexpress.com/article/explained/arth-ganga-govts-new-model-rivers-sustainable-development-8111967/>
- Gann, G. D., McDonald, T., Walder, B., Aronson, J., Nelson, C. R., Jonson, J., Hallett, J. G., Eisenberg, C., Guariguata, M. R., Liu, J., Hua, F., Echeverría, C., Gonzales, E., Shaw, N., Decler, K., & Dixon, K. W. (2019). International principles and standards for the practice of ecological restoration. Second edition. *Restoration Ecology*, 27(S1). <https://doi.org/10.1111/rec.13035>
- Gupta, P. (2021). *Ecosystem Restoration of Ganga River Basin*. [Www.Indiascienceandtechnology.gov.in](http://www.Indiascienceandtechnology.gov.in); Department of Science and Technology. <https://www.indiascienceandtechnology.gov.in/featured-science/ecosystem-restoration-ganga-river-basin>
- Gupta, R. (2022). Sahakar bharti signs mou to develop saharak ganga grams. *Sahakar Bharati Signs MoU to Develop Sahakar Ganga Grams*. <https://www.indiancooperative.com/featured/sahakar-bharati-signs-mou-to-develop-sahakar-ganga-grams/>
- Hariram, N. P., Mekha, K. B., Suganthan, V., & Sudhakar, K. (2023). Sustainalism: An integrated socio-economic-environmental model to address sustainable development and sustainability. *Sustainability*, 15(13), 10682. <https://doi.org/10.3390/su151310682>
- Jaiswal, D., & Pandey, J. (2021). Human-driven changes in sediment-water interactions may increase the degradation of ecosystem functioning in the Ganga River. *Journal of Hydrology*, 598, 126261. <https://doi.org/10.1016/j.jhydrol.2021.126261>
- Jaiswal, D., Pandey, U., & Pandey, J. (2021). Ecosystem responses to pollution in the Ganga river: Key issues to address river management. In A. Singh, M. Agrawal, & S. B. Agrawal (Eds.), *Water Pollution and Management Practices* (pp. 221–253). Springer Singapore. https://doi.org/10.1007/978-981-15-8358-2_10

- Jhariya, D. C., & Kumar Tiwari, A. (2020). Ganga river: A paradox of purity and pollution in India due to unethical practice. *IOP Conference Series: Earth and Environmental Science*, 597(1), 012023. <https://doi.org/10.1088/1755-1315/597/1/012023>
- Kala, C. P. (2011). Save Ganga campaign and hydroelectric projects in Uttarakhand. *Current Science*, 101(5), 596.
- Koshy, J. (2023). Seven years on, mission to clean the Ganga remains a work in progress. *The Hindu*. <https://www.thehindu.com/sci-tech/energy-and-environment/seven-years-down-cleaning-the-ganga-remains-a-work-in-progress/article67259400.ece>
- Kumar, A. G. (2022). *Sustainability is key to Ganga rejuvenation*. Hindustan Times; Hindustan Times. <https://www.hindustantimes.com/opinion/sustainability-is-key-to-ganga-rejuvenation-101654320684535.html>
- Mishra, S. (2023). 'Ganga bhog – gangotri se ganga sagar tak' initiative to promote awareness on millet farming in Rishikesh. Tractornews. In; Tractornews. <https://tractornews.in/news/ganga-bhog-gangotri-se-ganga-sagar-tak-initiative-to-promote-awareness-on-millet-farming-in-rishikesh/>
- Mohan, V. (2022). Clean Ganga mission launches initiatives to promote economic activities along river, tributaries. *The Times of India*. <https://timesofindia.indiatimes.com/home/environment/clean-ganga-mission-launches-initiatives-to-promote-economic-activities-along-river-tributaries/articleshow/93599219.cms?from=mdr>
- Mondal, P., Adhikary, P., Sadhu, S., Choudhary, D., Thakur, D., Shadab, M., Mukherjee, D., Parvez, S., Pradhan, S., Kuntia, M., Manna, U., & Das, A. (2022). Assessment of the impact of the different point sources of pollutants on the river water quality and the evaluation of bioaccumulation of heavy metals into the fish ecosystem thereof. *Int. J. Exp. Res. Rev.*, 27, 32-38. <https://doi.org/10.52756/ijerr.2022.v27.003>
- Mukherjee, P., Saha, A., Sen, K., Erfani, H., Madhu, N. R., & Sanyal, T. (2022). Conservation and prospects of Indian lacustrine fisheries to reach the sustainable developmental goals (SDG 17). In N. R. Madhu (Ed.), *A Basic Overview of Environment and Sustainable Development* (1st ed., pp. 98–116). International Academic Publishing House (IAPH). <https://doi.org/10.52756/boesd.2022.e01.010>
- National Mission for Clean Ganga. (2020). *Namami Gange Programme*. National Mission for Clean Ganga(NMCG), Ministry of Jal Shakti, Department of Water Resources, River Development & Ganga Rejuvenation, Government of India. <https://nmcg.nic.in/>
- NMCG. (2020). *Namami gange: Annual report 2019-2020*. National Mission for Clean Ganga Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti, Government of India. https://nmcg.nic.in/writereaddata/fileupload/32_English%20Annual%20Report%20of%20NMCG%202019-20.pdf

- PIB. (2022). *United nations recognizes namami gange initiative as one of the top 10 world restoration flagships to revive the natural world*. Ministry of Jal Shakti. <https://pib.gov.in/pib.gov.in/Pressreleaseshare.aspx?PRID=1883661>
- PIB. (2023). *Project artha ganga*. Pib.Gov.In; Ministry of Jal Shakti. <https://pib.gov.in/pib.gov.in/Pressreleaseshare.aspx?PRID=1984940>
- Rad, S. M., Ray, A. K., & Barghi, S. (2022). Water pollution and agriculture pesticide. *Clean Technologies*, 4(4), 1088–1102. <https://doi.org/10.3390/cleantechnol4040066>
- Sagarmala. (2021). *MARITIME INDIA VISION 2030*. Ministry of Ports, Shipping and Waterways; Government of India. <https://sagarmala.gov.in/sites/default/files/MIV%202030%20Report.pdf>
- Saha, A. (2023). Circular Economy Strategies for Sustainable Waste Management in the Food Industry. *Journal of Recycling Economy & Sustainability Policy*, 2(2), 1–16. Retrieved from <https://respjournal.com/index.php/pub/article/view/17>
- Saha, A., & Sarkar, C. (2022). Protecting The Precious Sundarbans: A Comprehensive Review of Biodiversity, Threats and Conservation Strategies In The Mangrove Ecosystem. *Conscientia*, 10, 60-80.
- Sanyal, T., Deb, H., & Mukherjee, S. (2017). Use of surface water to combat groundwater pollution: With special reference to Ganga water treatment plant of Chakdaha, Nadia, West Bengal. *International Journal of Engineering Sciences & Research Technology*, 6(9), 595–605. <https://doi.org/10.5281/zenodo.996020>
- Sanyal, T., Saha, A., & Mukherjee, P. (2023). Activities of fisheries co-operative societies in India to boost up and optimise the resources and economy of farmers: a review. *Journal of Fisheries*, 11(2), 112301. <https://doi.org/10.17017/j.fish.487>
- Serra-Llobet, A., Jähnig, S. C., Geist, J., Kondolf, G. M., Damm, C., Scholz, M., Lund, J., Opperman, J. J., Yarnell, S. M., Pawley, A., Shader, E., Cain, J., Zingraff-Hamed, A., Grantham, T. E., Eisenstein, W., & Schmitt, R. (2022). Restoring rivers and floodplains for habitat and flood risk reduction: Experiences in multi-benefit floodplain management from California and Germany. *Frontiers in Environmental Science*, 9, 778568. <https://doi.org/10.3389/fenvs.2021.778568>
- Sharma, M. K., Thayyen, R. J., Jain, C. K., Arora, M., & Shyamlal. (2022). Seasonal variations of major ion chemistry and solute fluxes of meltwater of river Bhagirathi, a Himalayan tributary, India. In R. Jha, V. P. Singh, V. Singh, L. B. Roy, & R. Thendiyath (Eds.), *Groundwater and Water Quality* (Vol. 119, pp. 387–398). Springer International Publishing. https://doi.org/10.1007/978-3-031-09551-1_32
- Shivanna, K. R. (2022). Climate change and its impact on biodiversity and human welfare. *Proceedings of the Indian National Science Academy*, 88(2), 160–171. <https://doi.org/10.1007/s43538-022-00073-6>
- Singh, A. K., Pathak, A. K., & Lakra, W. S. (2010). Invasion of an exotic fish—common carp, *cyprinus carpio* l. (Actinopterygii: Cypriniformes: cyprinidae) In the Ganga river, India

- and its impacts. *Acta Ichthyologica Et Piscatoria*, 40(1), 11–19. <https://doi.org/10.3750/AIP2010.40.1.02>
- Singh, D., Shukla, A. K., Yadav, S., Pandey, G., & Dutta, V. (2022). The Ganga river water pollution status in India characterize with river Gomti. *Ecology, Environment and Conservation*, 1636–1643. <https://doi.org/10.53550/EEC.2022.v28i03.074>
- Singh, R., & Singh, G. S. (2020). Integrated management of the Ganga River: An ecohydrological approach. *Ecohydrology & Hydrobiology*, 20(2), 153–174. <https://doi.org/10.1016/j.ecohyd.2019.10.007>
- Sinha, R. K., & Kannan, K. (2014). Ganges river dolphin: An overview of biology, ecology, and conservation status in India. *AMBIO*, 43(8), 1029–1046. <https://doi.org/10.1007/s13280-014-0534-7>
- Srinivas, R., Singh, A. P., & Shankar, D. (2020). Understanding the threats and challenges concerning Ganges River basin for effective policy recommendations towards sustainable development. *Environment, Development and Sustainability*, 22(4), 3655–3690. <https://doi.org/10.1007/s10668-019-00361-0>
- Srivastava, M. (2022). Upsc essentials: One word a day – arth-ganga. *The Indian Express*. <https://indianexpress.com/article/upsc-current-affairs/upsc-essentials/upsc-essentials-one-word-a-day-arth-ganga-8113349/>
- Sturbois, A., De Cáceres, M., Bifulchi, A., Bioret, F., Boyé, A., Gauthier, O., Grall, J., Grémare, A., Labrune, C., Robert, A., Schaal, G., & Desroy, N. (2023). Ecological quality assessment: A framework to report ecosystems quality and their dynamics from reference conditions. *Ecosphere*, 14(12), e4726. <https://doi.org/10.1002/ecs2.4726>
- UNEP. (2019). *New un decade on ecosystem restoration to inspire bold un environment assembly decisions*. UNEP. <http://www.unep.org/news-and-stories/story/new-un-decade-ecosystem-restoration-inspire-bold-un-environment-assembly>
- Vyas, J. N., Nath, S., Deogade, R. B., & Chandra, P. (2023). Rejuvenation of rivers in India: A case study on efforts for rejuvenation of river Ganga. In A. K. Gupta, M. K. Goyal, & S. P. Singh (Eds.), *Ecosystem Restoration: Towards Sustainability and Resilient Development* (pp. 137–147). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-3687-8_8
- WII. (2023). *Jalaj project overview*. Wildlife Institute of India. https://wii.gov.in/jalaj_project_overview

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